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COOPERATIVE RICE IMPROVEMENT PROGRAM IN THE PHILIPPINES

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IMPORTANCE OF RICE IMPROVEMENT

A little less than three million hectares are planted to rice each year and the average yield for 1954 was about 28 cavans[6] per hectare. The Philippines, which is about 93 per cent self-sufficient in food production, imports about two million cavans of rice every year. To keep up with the present rate of population increase, rice production in the country must be more than doubled in the next 20 years. One of the cheapest and most effective means of increasing rice production is the use of superior varieties.

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6 *One cavan of paddy weighs 43 kilograms.*

A BRIEF REVIEW OF RICE IMPROVEMENT PROGRAM

1. Setting up cooperative rice improvement Program. In order to bring about a coordinated effort for increasing rice yield, the College of Agriculture of the Philippine University, the Bureau of Plant Industry (BPI), the Bureau of Agricultural Extension (BAE) and the International Cooperation Administration (ICA) started in 1952 a modest rice and corn improvement program. Later in 1954, a memorandum of understanding was signed covering four projects: Improvement of Upland Rice, Improvement of Lowland Rice, Corn Improvement, and Seed Production and Distribution. This cooperative approach diminishes, if not eliminates, unnecessary duplications or wasteful competitions. The program has been so expanded that in the evaluation of rice varieties and corn hybrids, more than 20 experiment stations and farms all over the country are cooperating, as listed in the last section of this paper.

2. Evaluation of varieties followed by purification and multiplication. The two years of performance trials of commercially grown rice varieties (a total of 122 upland and 119 lowland varieties[1]) were completed and the results show that several varieties are significantly better than the varietes most widely grown at present.

As a result of these trials, it becomes possible to group the commercial upland and lowland varieties according to their performance. This information provides a basis to determine how to fertilize the different varieties of rice. It also tells which commercial varieties are sensitive to short days and therefore cannot be planted during certain time of the year. Furthermore it proves that a number of early-maturing varieties (130-150 days) can yield significantly more than many late-maturing ones. This finding drives a wedge into the common belief of many farmers that late-maturing commercial varieties like Wagwag (210 days), Elonelon (185 days) and Raminad (180 days) are always better yielders than early ones. Some of the high-yielding and early-maturing varieties are best suited to rainfed fields (44 per cent of our rice acreage is rainfed) which do not have enough water to mature a late-maturing variety. Under rainfed conditions in some parts of the country, it may be possible to grow two crops of rice a year - an upland rice from May to September, and when there is enough rain water for land preparation in October, an early lowland variety may be grown from November to the middle of March. In irrigated fields, two crops of early varieties of rice can easily be grown in a year, or one early crop of rice and a green manure crop, or one early crop of rice and a cash crop like mungo can also be grown.

In order to evaluate the results of the cooperative tests and to recommend the best varieties for multiplcation and distribution, a Seed Board, consisting of three members each from the College, BPI and BAE, was

1 The lowland varieties belong to four groups of maturity period-early (less than 146 days), medium-early (146-165 days), medium-late (166-175 days), and late (175 days or more)

created by the Secretary of Agriculture and Natural Resources (Special Order No. 616) on March 11, 1955. The Seed Board had its first meeting on April 15, 1955 to study thoroughly the results of the two-year trials of upland and lowland varieties. A total of 23 promising upland varieties were recommended for increase for "Foundation Seed" production in a one-half hectare field in the wet season of 1955 at the following stations of the Bureau of Plant Industry:

Lamao Hort. Experiment Station, Bataan	La Granja Station, Negros Occidental	Mindanao Central Expt. Station, Cotabato
Azucena	Azucena	Azucena
Fortuna	Fortuna	Fortuna
Makapilay Pusa	Makapilay Pusa	
Cotsiam	Cotsiam	
Binirhen Str. 366	Binirhen Str. 366	
Nira B		Nira B
Sinaba		Sinaba
Jaguari		Jaguari
Lady Wright		Lady Wright
Mangarez		Mangarez
		Salumpikit
		Twalibon
	Binicol	
	Magsanaya	
Guinata		
Kinandang Puti		
Milfor 6 (1)		
Palawan		
Binirhen		
Nagdami		
Pinulot		
Inabaca		
Lubang Puti		

Similarly, eleven lowland varieties were recommended for multiplication at the Maligaya Rice Experiment Station. These varieties are the following: B-6X27 (155 days), B-E-2 (130 days), B-E-3 (130 days), Baiang (130 days), Bengawan (150 days), Peta (135 days), Raminad Str. 3 (P) (194 days), S.K. Str. 482 (174 days), Tjereh Mas (140 days), Brondal Poetich (130 days) and Inomay (140 days). The number of recommended varieties may be reduced depending on their performances in 1955.

With the cooperation of the Agricultural Credit and Cooperative Financing Administration (ACCFA), the finally chosen varieties will be made available in large amounts of supply to farmers for planting in 1957. In an agreement signed on July 14, 1955 with the Bureau of Agricultural Extension, the Bureau of Plant Industry and the College of Agriculture, ACCFA agrees to help finance the production of registered and certified seed; store them in ACCFA warehouses and distribute them to the farmers.

Similar to ACCFA, the National Rice and Corn Corporation (NARIC) offers to purchase certified seed from cooperating growers and to help in the distribution to rice farmers. There is no doubt that NARIC can be of great help in the campaign for the extended use of certified seed, by refusing to purchase grower's crop if it is not grown from certified seeds or recommended varieties.

For regulation of the multiplication and distribution of the recommended varieties, a seed certification agency, under the supervision of BPI and BAE, will choose suitable farmers to grow certified seeds, supervise and inspect the crop in the field and analyze seed samples of the crop for purity and germination. The procedure of certification and distribution is embodied in the supplementary memorandum of understanding of the four organizations signed on December 28, 1954.

3. **Introduction of foreign varieties and observational plantings.** The College of Agriculture and Maligaya Rice Experiment Station have been collecting rice varieties from the country and abroad and growing them in observational nurseries to study their agronomic characters. For two years, more than 800 varieties were grown in observational plantings and from them 43 promising upland and 28 lowland varieties were selected and included in performance trials.

Since March, 1955, 195 upland and 174 lowland varieties have been planted every two months under lowland conditions to find out their sensitivity to short days, and to determine the best time of planting for those sensitive ones. They are also being studied for characters which may be of value for breeding purposes. Majority of the upland varieties have performed well under lowland conditions. In fact, most of them made better performances in lowland than in upland. From them, it is hoped that high-yielding varieties will be selected. These upland varieties together with 124 early-maturing lowland ones have also been planted under upland conditions to see how the latter varieties behave under rainfed conditions.

The world collection of 2,362 varieties received from USDA are now being grown in lowland observational nurseries in both the College of Agriculture and Maligaya Rice Experiment Station. It is expected that they can be screened as rapidly as possible for promising varieties and strains adapted to lowland conditions and with desirable agronomic characters, such as stiff straw and insect and disease resistance, which can be

used in future breeding work. The early-maturing ones in this collection will be grown under upland conditions next year. As of November 20, 1955, about 40 per cent of the collection headed in about two months after planting in lowland nurseries.

4. **Breeding for better strains.** The only breeding work on rice currently conducted in the College of Agriculture is the segregating of progenies from the *Indica–Japonica* crosses made in Cuttack, India under the FAO International Rice Hybridization Project. Out of more than 500 F_4 progeny lines being studied under upland conditions, only 21 seem to be somewhat promising. Line selections from the Wagwag variety have just been completed and recently a few crosses have been made for breeding resistance to lodging.

In Maligaya Rice Experiment Station, 25 F_4 lines of the *Indica-Japonica* crosses were selected as promising under lowland conditions. A considerable amount of hybridization work with local varieties has been conducted in this station; and a few short–strawed, high–yielding strains have alreday been developed and are now ready for testing in different rice regions of the country.

5. **Experiments on methods of rice cultivation.** It is a common sense that the use of superior varieties alone cannot give a maximum yield. Increased production can only be achieved by applying all the sound practices of crop production. Towards this end, the Division of Plant Breeding of the College of Agriculture is investigating the cropping systems best suited to rainfed and irrigated fields, the effects of rate of seeding or spacing, depth of planting and density of seeding in seedbeds on yield, the nature and causes of lodging and its effect on yield, ratooning capacity of different rice varieties, cash crops for lowland rice fields, and appraisal of the Margate System[1] in the dry season as well as in the regular crop season.

6. **Inter–departmental cooperative research in the College of Agriculture.** Since the multifarious problems of rice production need a concerted attack, the Division of Plant Breeding is conducting cooperative researches with different departments of the College as follows: with the Department of Agricultural Botany on chemical weed control in rice fields; with the Department of Soils on variety–fertilizer interaction and on the effects of nitrogen fertilization on lodging; with the Department of Entomology on the control of stem borers and sucking bugs and on the reaction of some promising varieties to these destructive insects; with the Department of Plant Pathology on reaction of some promising upland and lowland rice varieties to four major diseases of rice; with the Department of Agricultural Engineering on irrigation management and on factors affecting milling recoveries; with the Department of Agricultural Engineering on irrigation management and on factors affecting milling recoveries; with the Department of Agricul-

1 *Refers to the so-called "Japanese method of rice cultivation"*

tural Chemistry on nutritional and keeping-quality studies of polished rice; and with the Department of Home Technology on cooking and eating qualities of rice.

PROJECTS PLANNED FOR 1956

Project 1. **Breeding superior varieties of upland and lowland rice.**

Of the four phases of the Cooperative Rice Improvement Program—variety evaluation, observational planting, purification of varieties, and hybridization—the first and the last especially need more intensive studies. Out of a large number of the local and introduced varieties so far studied, not single one possesses all the desired agronomic characters suited to the growing conditions in the country. In fact, about 99 per cent of the varieties grown lodge badly and hardly respond to fertilization. As rapidly as possible, an extensive hybridization or crossing program in cooperation with entomologists, plant pathologists and soil specialists should be started to produce varieties that are early-maturing, for dual-purpose[1], short strawed, of good standing ability, resistant to shattering and to major insect pests and diseases, responsive to fertilization, medium to longgrained, high in milling recovery, of good cooking and eating quality, and of course, high-yielding. An essential feature of a successful breeding program is the growing of a large number of plants so that lines having the desired combinations can be selected. The program can be greatly speeded up by growing 2 or 3 generations a year for the first few generations.

Project 2. **More intensive testing of varieties in different regions under different fetility levels**

Especially with lowland rice, a more intensive and careful testing of varieties should be carried out. Performance trials should be conducted in more regions of the country and if possible, at different localities within the region.

In 1955 there were ten stations cooperating in lowland rice trials, as against six stations in 1954. But only two stations had valid data that could be summarized. So a two week training course is now planned for the people cooperating in the field trials.

In cooperation with the soil specialists, the fertility level on which the recommended varieties will perform best in different regions will be studied in 1956.

EXPERIMENT STATIONS AND FARMS FOR RICE IMPROVEMENT WORK IN THE PHILIPPINES

1. Mindanao Central Experiment Station, Cotabato
2. Mindanao Agricultural College, Musuan, Bukidnon

1 Meaning rice varieties that can be grown successfully under both upland and lowlannd conditions.

3. Davao Penal Colony, Davao
4. Davao Abaca Experiment Station, Davao
5. Ilagan Tobacco Experiment Station, Isabela
6. San Carlos Agricultural High School, Pangasinan
7. Iwahig Penal Colony, Palawan
8. Nueva Viscaya High School, Bayombong, N.V.
9. Pili Agricultural Hign School, Pili, Camrines Sur
10. Economic Garden, Los Banos, Laguna
11. Mt. National Agricultural School, Mt. Province
12. Indang Rural High School, Indang, Cavite
13. Maligaya Rice Experiment Station, Munoz, Nueva Ecija
14. Lamao Horticultural Experiment Station, Limay, Bataan
15. Sablayan Penal Colony, Occidental Mindoro
16. Central Experiment Station, College, Laguna
17. A Private Farm (Tabon, Bay, Laguna)
18. La Granja Sugarcane Experiment Station, Negros Occ.
19. Samar Agricultural High School, Gandara, Samar
20. Central Philippine University, Dumaguete
21. Baybay National Agricultural School, Baybay, Leyte

THE EFFECT OF CROP ROTATION ON THE GROWTH AND YIELD OF RICE IN THE UNITED STATES

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The cropping system for rice (*Oryza sativa L.*) in the United States varies with the soil type, drainage and climate. Soil types on which rice is grown include silt loam, clay loam, clay, adobe clay, and fine sandy loam. In most, but not all, rice areas the soil drains sufficiently for the growing of winter crops such as small grains and forage legumes, following rice harvest. The small grain crops sown in the rice areas near the Gulf Coast are used only for pasture or green manure, because the humid climate and accompanying plant diseases preclude profitable grain production. In the Mississippi Valley and Gulf Coast areas, crops are grown without irrigation, but in California, other summer crops are rarely grown on rice lands. In all areas, prices and market outlook are important factors in choosing a crop to rotate with rice.

Satisfactory yields of rice cannot be produced under continuous culture because of the reduction in the amounts and availability of plant nutrients, and because of the

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accumulation of weeds, grasses and rice diseases. Rotation with other crops also restores the physical condition of the soil.

The Wabash clay (gumbo) and Sharkey clay (buckshot) and similar soils in the Mississippi River Valley are naturally rich in organic matter and mineral nutrients, but are difficult to cultivate except with heavy mechanical equipment. These soils produce high yields of rice and other crops when properly drained. Experiments in Missouri reported by King (3) demonstrate that crop rotation is essential to high rice yields on Wabash clay soils.

The yields on continuous rice plots declined from an average of 4,428 pounds to 450 pounds in a 6-year period owing to infestation with sedges, grasses "and a variety of other aquatic and semi-aquatic weeds." The yield of rice in the 2-year rice-soybean rotation ranged from 2,907 pounds to 5,944 pounds per acre during the 6 years. Similar rice yields were obtained in four different 4-year rotations that involved other crops such as soybeans (*Glycine max* Merrill), wheat (*Triticum vulgare* Vill.), clover and corn (*Zea mays L.*). Consequently the 2-year rotation was recommended because a greater proportion of the cultivated area could be devoted to rice.

On Sharkey clay soils in the Mississippi Valley, rice often is grown in rotation with soybeans or lespediza (*Lespedeza striata* Hook & Arm) as summer crops or with rough peas (*Lathyrus hirsutus*) as a winter crop. No well-controlled rice rotation experiments have been conducted on this soil.

On Crowley silt loam soil in Arkansas, the yields of rice declined from 2,232 pounds to 1,606 pounds per acre during 10 years of continuous rice culture, according to Nelson (5). In four 2-year rotations of rice and soybeans, the yields of rice were significantly higher than where rice was grown continuously, particularly where the soybeans were grown in intertilled rows. In other 2-year rotations, lespedeza and soybeans, as alternate crops, increased the yield of rice more than did cowpeas (*Vigna sinensis* Endl.), cotton (*Gossypium hirsutum* L.), corn or volunteer vegetation.

Nelson (6) compared the yields of rice following the winter cover crops: hairy vetch (*Vicia villosa* Roth), crimson clover (*Trifolium incarnatum* L.), Austrian winter pea (*Pisum arvense* L.), sweet clover (*Melilotus alba* Med.), bur clover (*Medicago hispida* Gaertn.) and rye (*Secale cereale* L.) with no cover crop during a 9-year period. The hairy vetch rotation produced the highest rice yields, averaging 283 to 603 pounds per acre more than no cover crop. Crimson clover and Austrian winter peas plowed under also produced yields significantly higher than the check. Sweet clover and bur clover were less beneficial because of limited vegetative growth, but good yields of rice were obtained following bur clover that had made satisfactory winter growth. Rice yields following rye were low because of the low nitrogen content of the rye that was plowed under.

The favourable crops, alternating with rice supplied nitrogen, improved the physical

condition of the soil, and reduced the competition with weeds and grass, which resulted in higher yields and more uniform stands of rice than in continuous rice culture.

During the first 25 years that rice was produced in Arkansas, the usual practice was to grow rice continuously as long as profitable yields could be obtained and then the field was left idle without cultivation for a year or two before being put back to rice. Rice yields under this system declined about 50 per cent, but then remained fairly stable. Cropping systems were then adopted in which rice is grown every third year in rotation with soybeans, lespedeza and fall-sown oats. Typical rotations in Arkansas are: (1) rice followed by 2 years of soybeans or lespedeza, and (2) rice followed by soybeans, followed by fall—sown oats *Avena byzantina* C. Koch) in which lespedeza is sown for a summer crop following oat harvest. In the latter rotation four crops are harvested in 3 years. It is a common practice to apply phosphorus and potassium fertilizers to the other crops in the rotation, and to apply nitrogen as a top dressing to the rice crop.

In a sample survey Slusher (9) found that 75 per cent of the rice farms in Arkansas had supplemental crop or livestock enterprises. The main supplemental crops were oats, lespedeza, soybeans, corn and cotton.

Harvested crops are seldom grown in rotation with rice in the Gulf Coast area of Louisiana and Texas (Jones, et al) (2) because the yields of oats, soybeans, cotton, corn and peanuts *(Arachis hypogeae L.)* are seldom profitable. The most common practice in this area is to grow one or two crops of rice and then to pasture the fields with cattle for one to four years. Formerly, native volunteer grasses were depended upon to furnish forage for grazing. Now the fields are fertilized and seeded with cultivated grasses and legumes which greatly increase the carrying capacity of the pasture and improves the productivity of the soil for rice. Reynolds (8) reports that in Texas annual beef gains of 200 pounds per acre are possible from improved pastures, as compared to less than 50 pounds for unseeded, unfertilized pasture fields. Rice yields were 2,500 to 2,860 pounds per acre following improved pastures compared to about 1,800 pounds following unimproved pasture. Moncrief and Wiehing (4) report that the legumes seeded in improved pastures in rice rotations are white *(Trifolium repens L.)*, Ladino (*Trifolium repens L.*), red *(Trifolium pratense L.)*, Persian *(Trifolium resupinatum L.)* subterranean *(Trifolium subterraneum* L.), crimson, alsike (*Trifolium hybridum* L.) and Lappa (*Trifolium lappaceum* L.) clovers, and lespedeza. The clovers most commonly used are white, hop (*Trifolium agrarium* L.), Persian and red in the more humid east Texas area and annual sweet clover in the drier western area. Grasses seeded are dallas (*Paspalum dilatatum* Poir.) fescue (*Festuca* elatior L.) and rye grass *Lolium multiflorum* Lan. Bermuda grass (*Cynodom dactylon* L.) usually comes in as a volunteer grass. Walker and Sturgis (12) found

in Louisiana that rice following improved pasture produced 1,418 pounds per acre more than when rice followed unimproved pasture. Increases in beef production of from 75 to 214 pounds per acre were obtained by seeding and fertilizing the pastures.

Sturgis (10) found that the yield of rice on deflocculated Crowley silt loam soil was not increased by 600 pounds per acre of 8-8-8 fertilizer until organic matter was added to improve the soil structure. Long continuous culture of irrigated rice changed the character of coastal prairie soils in several respects. The colloids were deflocculated, the reaction of the soil was increased from pH 6.0 to pH 7.1 and large amounts of colloidal iron and silica accumulated. The nitrogen content of the soil was reduced from 0.20 per cent to 0.08 per cent, soluble and readily available phosphorus from 12.5 p.p.m. to 4.5 p.p.m.; and exchangeable potassium reduced from 100 to 61 p.p.m.

Sturgis and Reed (11) report benefits to the growth and composition of rice on a deflocculated Crowley silt loam soil from treatments including rotation with soybeans and the application of nitrogen, phosphorus, and potash in various combinations. Soybeans alone gave a slight increase, with a marked increase from the further addition of phosphorus. The greatest improvement in rice yields followed the addition of nitrogenous materials in combination with phosphorus and potash. However, virgin soil produced higher rice yields than did any of the treated deflocculated soils. Rice grain produced on the deflocculated soil was lower in nitrogen, phosphorus, sulfur and magnesium and higher in ash, silica, calcium and iron than that produced on virgin soil. Rice grown on treated deflocculated soil was intermediate between that on untreated deflocculated soil and that on virgin soil, in its content of nitrogen, sulphur, calcium and magnesium. Changes in the content of silica, calcium and iron as a result of treatment were rather variable.

Reed and Sturgis (7) reported that the addition of leguminous organic matter was the most effective treatment for improvement of the physical condition of soil deflocculated by long continuous rice culture.

According to Jones, *et al* (1) no definite system of crop rotation is followed in California. The heavy soils on which rice is grown and the prevailing high water table during the irrigation season make it difficult to grow any crop profitably in rotation with rice. One system on new land is to summer fallow the field after two or three crops of rice and then sow barley (*Hordeum vulgare* L.) or wheat in the fall. These grains mature in the spring before the water table is high enough to cause damage. By this system one rice crop is produced in 3 years.

At the Biggs Rice Experiment Station attempts have been made to grow cultivated crops in rotation with rice, but neither corn, grain sorghum (*Sorghum vulgare* Pers.), cotton or beans (*Phaseolus vulgaris* L.) produced a profitable crop. Field peas, beans and grain sorghums are sometimes grown in rotation with rice on the higher

lands where the water table is lower. These other crops sometimes are grown in overflow areas when the flood waters are not drained off early enough to sow rice.

Some fields that formerly were cropped to rice are seeded to permanent pasture of ladino clover and grasses. These pastures are irrigated and promptly drained at 7-day to 14-day intervals throughout the summer. Much of this land has remained in permanent pasture but good yields are received when such pastures are plowed up and sown to rice. Improved pastures should be plowed in the previous fall or early spring to permit the vegetation to decompose by the time the rice field is submerged.

Purple vetch (*Vicia atropurpurea* Desf.) one of the most common winter cover crops for rice fields is sown by airplane when the rice field is drained. The vetch makes considerable growth during the mild winter and is plowed under in early spring in preparation for rice. This winter cover crop system favours a maximum acreage of rice on the farm.

All rice in California is sown in the water, and this method usually controls most of the grasses. Chemicals such as 2, 4-D can be used to control many of the broad leaf weeds. With the use of nitrogen fertilizer, several profitable crops of rice are obtained before it is necessary to take the field out of production. The common practice is to plow the field in the spring and keep it fallow during the summer. Some growers merely allow the land to lie idle for a year except that it often is pastured. This system partly controls aquatic weeds and releases avilable mineral nutrients in the soil.

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RESEARCH ON PENYAKIT MERAH IN MALAYA

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In 1954 a sub-committee was formed in the Malayan Department of Agriculture to outline a program of research on the rice disease known as *penyakit merah.* The first field experiments planned by the sub-committee, which comprises the Senior Plant Pathologist, Senior Chemist (Soils), and Plant Physiologist, were laid down in 1955 and are currently running; this report will deal mainly with the work in progress.

A preliminary description of *penyakit merah* symptoms and a brief review of the course of the disease is given in a paper by Coulter and Lockard (1).

Soil Inspection

During the off-season from March until June, the Senior Chemist (Soils), with the help of the author, inspected the soil in 28 places where *penyakit merah* had been reported during the last two years. These included nearly all of the important rice growing districts in Malaya. In dry areas pits were dug to a depth of five feet; in places where the water table was high, a hole was dug to the water table and auger borings were taken below that to a depth of four feet. Notes were made on the physical structures and the colours of the horizons

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and samples of soil were taken from each horizon for a chemical analysis. Notes were also taken, at each place, on the depth to the water table, weed growth, and other pertinent facts on the off-season conditions.

Fertilizer Experiments

From the 28 areas in which the soils were inspected, 19 were selected for a fertiliser experiment. This was designed to test the effect of phosphate, dolomitic lime and sodium nitrate (for its addition of oxygen to the soil) when applied as fertiliser plus foliar sprays of phosphorus and of manganese on the severity of *penyakit merah*.

One of the most difficult problems in experiments of this type is to evaluate the effects of the treatments. In addition to yield records and tiller counts an attempt will be made to take sample leaf counts from each plot at the boot ear stage with the object of determining the percentage of morbid and dead leaves. The accuracy of this method will depend on

(a) the variability in the number of leaves produced by plants of one variety (total counts will be made for several varieties), and

(b) whether it is possible, by visual means, to determine if *penyakit merah* has been responsible for the dead leaves.

This method should, in any case, give information on the effect of treatment on the physiological disorders of the plant, of which *penyakit merah* is considered to be one.

From the areas in which the fertilizer trials have been laid down, leaf samples are being collected for analysis. This collection begins at approximately four weeks after transplanting and continues at monthly intervals, until the plants are in the boot ear stage. Analyses of these leaves will include determination of the nitrogen, phosphorus, potassium, calcium, and magnesium content. It is not expected that every area will show *penyakit merah* this year so samples from these areas plus samples from other areas considered to be healthy will be used as controls.

Varietal Resistance

Reports have come in from the field staff that some varieties seem to be resistant to *penyakit merah* while other varieties appear to be susceptible. For this reason variety trials were set out on six rice testing stations in various parts of Malaya as well as at headquarters, in Kuala Lumpur.

There were three varieties put on each station but these were chosen from five varieties. Both susceptible and resistant varieties were included in each area. Two varieties used were considered to be resistant, Seri Raja and Siam 29; and three were considered to be susceptible, Reyong 6, Mayang Sa Gumpal, and Machang. At headquarters all five are being tested plus Serendah Kuning. Not much is known about the resistance of this latter variety but it is expected to be intermediate in resistance.

The total number of leaves produced by each variety will be determined on a

sample of twenty plants (but only in one location). From these data it is planned to calculate the percentage of morbid and dead leaves at the boot ear stage and relative resistance will be based on these figures.

Stagnant Water

Of five tanks in which the susceptible and resistant varieties of rice are being tested, in Kuala Lumpur, three have been covered over and the water allowed to stagnate. The symptoms of ***penyakit merah*** are already present and from visual observations the plants in stagnant water appear to be worse than those in fresh water.

The soil used in these tanks is from Tanjong Karang in Selangor and is considered to be a good soil for rice growing.

Nematode

Very little is known about the nematodes which occur in Malaya, but Pratt in 1911 stated that injury by nematodes, probably *Tylenchus*, ranked second only to insufficient drainage as a cause of rice crop losses in Krian (2). Van der Vecht and Bergman (6) reported that nematode injury was associated in Indonesia with "mentek", a disease considered to be similar to ***penyakit merah***. When a program of research on ***penyakit merah*** was drawn up, it was, therefore, decided that the occurrence of nematodes in some rice growing areas of Malaya should be investigated.

During the current rice growing season, root samples are being collected periodically from areas where the fertilizer trials, referred to above, were laid down. These samples are taken at random from a group of approximately ten plants growing near the fertilized area. The root samples are collected in plastic bags and sent as quickly as possible (usually in less than twenty four hours) to the Senior Entomologist, who has undertaken to extract the nematodes and to arrange for their identification. The nematodes are extracted in the manner described by Van der Vecht and Bergman (6) except that surgical gauze is used in addition to the muslin wrapping, as a filter.

Nematodes were found in each of the first five samples collected. From this group one sample was sent to Mr. J.B. Goodey at the Rothamstead Experimental Station in the United Kingdom. The majority of these nematodes proved to be of a parasitic type, ***Radopholus oryzae*** V. Breda de Haan (which was found also in Java) and the rest were a saprophytic type, *Chronogaster sp.*

With one exception, the numbers of nematode collected from roots in all locations that have been sampled to date appear to be correlated with the severity of the visual symptoms of ***penyakit merah***. Root samples have not yet been taken from areas which appear to be unaffected by ***penyakit merah***, and so no conclusions can yet be drawn concerning a relationship between the incidence of the disease and the occurrence of parasitic nematodes.

Iron and Aluminium

Observations in Malaya have indicated that ***penyakit merah*** is associated with a high

level of available iron in the soil. For example, analyses of rice leaves collected from healthy and diseased plants from the same areas showed that leaves from diseased plants nearly always contained more iron. Also, plants from fields in which the disease was severe usually had black roots. There are indications that the black colour is an iron compound (probably ferrous sulphide).

It is possible that *penyakit merah* is a result of the fixation of phosphorus in the plant tissue by excess aluminium, as this condition does occur in other plants (3, 4, and 5) Some Malayan soils are known to be high in aluminium and in iron.

In order to determine whether *penyakit merah* is caused by high concentrations in the soil of iron or of aluminium, a sand culture experiment was set up in which rice plants were grown in either excess iron or excess aluminium.

Difficulty was experienced in maintaining high concentrations of iron in solution. The iron was precipitated from both ferric citrate and ferrous sulphate and it was therefore necessary to use iron chelated with the sodium salt of ethylene diamine-tetra-acetic acid.

The control plants were grown in 6 p.p.m. of iron; those in excess were at 20, 50, or 100 p.p.m. of iron. The aluminium treatments were at 0.8, 2, and 4 p.p.m. while no aluminium was added to the control solution.

None of these treatments caused *penyakit merah* to appear on the plants. Severe symptoms of iron toxicity were observed in plants grown in 50 and 100 p.p.m. of iron. The plants in excess aluminium showed almost no abonrmalities. The addition of 2 p.p.m. had more of an adverse effect on plant growth than did 4 p.p.m.

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WET PADI MANURIAL EXPERIMENTS ON PEAT SOILS IN MALAYA

E.F. Allen [1] and J.K. Coulter [2]

Introduction

Peat and other bog soils cover large areas of alluvium in Malaya, perhaps more than 1,000,000 acres (404,680 ha.). Where these have been recently cleared of forest the loss on ignition may be as high as 95–98% and the pH 3.3–4.0, although the surface horizon is often less acid, especially after the burning associated with dryland cropping. Similarly the loss on ignition decreases with progressive mineralization of the surface layers, this being accompanied by shrinkage and subsidence of the surface.

Utilization

Certain dryland crops particularly pineapples, can be grown on peat soils quite successfully but tree crops are not usually successful unless the initial depth of true peat is less than 3 ft. Potash and copper are key elements in pineapple nutrition on peats.

Between 1947 and 1950 attempts were made to grow wet padi on peat at Chenderong Balai, Perak, but these were generally unsuccessful and it was then decided to abandon mechanized trials but to continue with fundamental investigations in an attempt to solve the long-term problems of wet padi cultivation on these soils.

Soil Characteristics

These have already been fully described (1) and soil analysis data are summarized in Table I.

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Table I

Site	Depth of peat or muck	Loss on ignition %		pH		Dete of Sampling
		0–6"	6–18"	0–6"	6–18"	
Chenderong Balai	$2\frac{1}{2}$ ft.	44	68	5.0	5.1	24.3.49
Padang Kemunting	+9 ft.	51	75	4.2	4.1	15.10.52

EXPERIMENTS WITH MAJOR ELEMENTS

NPK Factorial at Chederong Balai. This trial was laid down in 1952 and continued for three seasons with the object of determining the effect of NPK on the growth and yield of wet padi. The layout consisted of a 2^3 factorial arranged in 10 blocks of 4 plots each. Plot size was 33 × 33 ft. (1/40 acre). The treatments tested were:

N – 47 lbs./a (53 kgs./ha.) N as sulphate of ammonia
P – 166 „ (186 „) P_2O_5 as Christmas Island rock phosphate
K – 134 " (150 „) K_2O as muriate of potash (KCl)

The phosphate and potash were applied before transplanting and the nitrogen placed in the soil about 7 weeks later.

Yields of grain for the three seasons are summarized in Table II. It will be seen that yields were very low in all three seasons but there was an improvement in the last season. In 1952-53 there was a clear response from phosphate but no other differences were significant.

Table II – Effect of Treatments on Yield of Wet Padi at Chenderong Balai, Perak.

	1951 – 52		1952 – 53		1953 – 54	
	lb./a	kg./ha.	lb./a	kg./ha.	lb./a	kg./ha.
N	–70	–78	–14	–16	–118	–132
P	60	67	262	294	–26	–29
NP	46	52	–32	36	102	114
K	48	54	32	36	–30	–34
NK	24	27	–50	56	54	61
PK	14	16	19	21	64	72
Standard Error	±50.167	±56.232	±58.90	±66.02	±80.783	±90.550
Mean Yield	292	327	295	331	795	891

BLNPK Factorial at Padang Kemunting. This trial was laid down in Trengganu on a deep peat soil in 1953 with the following treatments :

B — surface peat burnt early in the year.

L — 1 ton/acre (2,511 kg./ha.) ground magnesium limstone applied early in the year.

N — 55 lb./acre (62 kg./ha.) N applied as nitrate of soda, 1/3 before planting and 2/3 about 6 weeks later.

P — 40 lb./acre (45 kg./ha.) P_2O_5 as double phosphate applied before transplanting.

K — 30 lb./acre (34 kg./ha.) K_2O as muriate of potash applied before transplanting.

This was repeated in the 1954-55 season on a fresh site. At the same time the first trial was repeated, for residual effects, with only the burn treatment reapplied.

Harvest yields are summarized in Table III.

Table III — Wet Padi Cultivation on Peat Soil at Padang Kemunting. (Main effects and 2-factor interaction effects on yields of grain and straw and number of tillers.)

	1953–54 season			1954–55 season–residual			1954–55 season–fresh land		
	grain lb./a	straw lb./a	tillers no.	grain lb./a	straw lb./a	tillers no.	grain lb./a	straw lb./a	tillers no.
B	Crop failure	515	2.4	678[3/]	2610[3/]	9.53[3/]	471[3/]	1781[3/]	5.13[3/]
L		246	3.0[1/]	155[1/]	474	2.87[1/]	232[1/]	534	1.12[2/]
BL		−523	.2	−21	392	2.45	120	101	−2.25[3/]
N		127	1.4	71	−116	1.82	37	1453[1/]	55
BN		254	.7	78	−243	.58	−164	−713	3.25[3/]
LN		−134	1.6	34	190	.80		146	1.59[3/]
P		1158[2/]	9.0[3/]	633[3/]	1976[3/]	7.07[3/]	1315[3/]	6330[3/]	8.87[3/]
BP		45	.8	9	26	1.88	−381[2/]	−930	−2.64[3/]
LP		254	.5	−65	−362	−2.74	97	−26	.06
NP		209	1.5	19	−41	.44	52	952	.09
K		560	3.8[1/]	−56	−422	.82	67	335	3.52[3/]

	1953–54 season			1954–55 season–residual			1954–55 season–fresh land		
	grain lb./a	straw lb./a	tillers no.	grain lb./a	straw lb./a	tillers no.	grain lb./a	straw lb.a	tillers no.
BK	Crop failure	–164	–0.4	11	93	1.26	30	–467	1.17 2/
LK		–209	–1.5	116	437	.78	134	–385	–2.02 3/
NK		–60	1.0	–9	280	.63	179	654	.68 1/
PK		627 1/	3.4 1/	41	–108	–.83	–7	452	2.55 3/
SE		±277.22	±1.299	±56.938	±270.81	±1.3094	±99.995	±516.404	±0.2973
Mean		1188	14.28	796	3087	13.88	1098	5133	12.67

N.B.: Significance at 5%, 1% and 0.1% indicated by 1/, 2/ and 3/

In the first season the crop failed because of lack of rain and heavy attack by *Scotinophara coarctata*. Nevertheless, it was possible to detect a significant effect of P, especially in the presence of K, to both straw yield and tillering.

When this trial was repeated on the same site after re-burning the B plots but with no other new treatment there was revealed a highly significant residual response to P from yields of grain and straw and from tiller number. There was also a small residual effect on yields and tillering from liming.

The same trial on fresh land in the 1954–55 season confirmed the highly significant effect of phospate and burning on the subsequent yields of grain and straw and on tillering. The actual yields of grain from these treatment combinations were as follows:

P 1710 lb./a or 1917 kg./ha.
B 866 lb./a or 971 kg./ha.
BP 1800 lb./a or 2018 kg./ha.

These yield figures reveal clearly the meaning of the negative BP interaction.

Liming had a small beneficial effect on yield of grain while nitrogen increased the yield of straw by a small amount.

Tillering was increased by the B, P, K and L treatments and both N and K enhanced the beneficial effect of B, whereas the following treatment combinations did not have additive effects: BL, LN, BP, LK.

From the practical viewpoint phosphate is clearly all important, while surface burning is beneficial to a lesser extent. This result ties up, to a certain extent, with the observed benefit from phosphate at Chenderong Balai in 1952-53 (vide Table II). It is interesting to speculate as to the reason for the small

response at this locality. Was it tied up with the use of the water insoluble rock phosphate or was it an ecological effect? This point is now under investigation.

This very promising result from Padang Kemunting is of very great interest as it is the best padi crop which has ever been grown on peat soil in situ in Malaya. It is perhaps important that this station is dependent on rainfall and is well drained whereas Chenderong Balai is irrigated but has very poor water control. It is possible, therefore, that the dissolved oxygen in the soil – water is an important limiting factor of yield on peats.

Observations on shallow peat and muck soils at Parit Satu, in the Tanjong Karang area of Selangor are also in progress but poor drainage has limited yields here. There is some indication that best results can be obtained by growing a Kelantan dry padi variety on such soil but naturally yields are dependent on rainfall.

EXPERIMENTS WITH MINOR ELEMENTS

Observation at Chenderong Balai. The effect of copper, zinc, boron, manganese and molybdenum have been tested for two seasons in duplicated plots with one set given a complete dressing of major elements. The following dosages were used:

Fertilizer	Quantity per acre
Copper sulphate	25 lb.
Zinc sulphate	25 lb.
Borax	15 lb.
Manganese sulphate	20 lb.
Amonium molybdate	10 lb.

All these were sprayed on about 7 weeks after transplanting at the time of application of a nitrogen top dressing. A wetting agent was added to the spray liquids.

The crop was destroyed by pests in the first season and no results were obtained: in 1953–54 a fair crop was harvested and yields are summarized below:

Minor Elements	With Major Elements (lb./acre)	Without Major Elements (lb./acre)
Cu	1,120	800
Zn	1,010	850
Mo	1,220	850
B	1,180	970
Mn	1,540	960

It was observed that the copper spray caused severe scorch so this element is perhaps best applied as Bordeaux mixture. Copper is known to be essential for the healthy growth of pineapples on dry peat and it is probably also of benefit to coffee.

Observation at Padang Kemunting. In 1954–55 an unreplicated series of plots were laid down on deep peat after burning and liming and all plots also received NPK. The treatments were as follows:

Element	Fertilizer	Rate per acre of fertilizer (lb./acre)	How applied
Cu	Copper sulphate	$12\frac{1}{2}$	As spray
Mn	Manganese sulphate	20	„
Fe	Ferrous sulphate	15	„
B	Borax	15	„
Zn	Zinc sulphate	15	„
Mo	Ammonium molybdate	10	„
All	All six	all	„
All	"Fritted trace elements"	100	To soil

The "fritted trace element" fertilizer is a synthetic sand which is said to release small quantities of trace elements in the soil over an extended period.

The mean yield of grain was 1,823 lb. per acre. Each element was applied to two plots systematically to achieve duplication and the results are summarized below:

Treatment	Yield of grain (lb./acre)	Yield of straw (lb./acre)	Tillers per hill (mean)
Zn + Cu	1,440	6,300	12.0
Cu + Mn	1,620	7,920	13.2
Mn + Fe	2,340	7,380	10.6
Fe + Mo	1,980	7,920	12.0
Mo + B	1,800	7,740	10.5
B + Zn	1,980	8,280	13.0
All	1,800	8,820	17.1
All fritted	1,620	6,480	11.9

The high tillering in the plot which received all elements in spray form was associated with damage by leaf–eating caterpillars and should be ignored.

When the effects of each element are extracted from the above figures they suggest that copper was perhaps harmful and iron perhaps beneficial. The differences were, however, very small and the chief value of the observation was the experience gained in the application of minor elements in spray form.

Factorial Experiment at Chenderong Balai. In 1954 a properly designed experiment was

laid down at Chenderong Balai, Perak, to test the effect of Cu, Zn, Mo, B and Mn using the same fertilizers and dosage rates as at Padang Kemunting in the same season. The whole area received 4 cwt. per acre each of Christmas Island rock phosphate and ground magnesium limestone before the last cultivation but no other major elements were given. All the minor elements were applied in spray form, the copper as Bordeaux mixture.

Fritted trace elements were tested in one extra plot in each of the four blocks so the design adopted was $2^5 + 1$ with 9 plots block.

The simple effects are summarized in Table IV.

Table IV — Effects of Minor Elements on Padi at Chenderong Balai.

Element	Effects in lb. per acre		
	Grain	Straw	Tiller number
Cu	–204	–325 N.S.	0.425
Zn	–86	159	–0.05
Mo	–107	98	0.65 N.S.
B	–6	83	–0.05
Mn	31	–250	–0.162
S.E.	±61.7644	±212.2998	±0.3270
Mean	410	2840	7.99

The very low yields were associated with stem-borer damage but the results confirm the harmful effect of copper.

This trial is being repeated on a fresh site but there is no indication that the absence of any trace element is a limiting factor of padi yield on deep peat in Malaya. This is in line with results from pot experiments.

Summary

1. Peat and muck soils probably cover more than 1,000,000 acres of alluvium in Malaya.

2. Early attempts to grow padi on peat soils were not successful, perhaps because of difficulties of water control and anaerobic conditions in the soil—water.

3. At Padang Kemunting, Trengganu, which is dependent on rainfall for its water supply, the peat is over 9 ft. deep with a pH of 4.1. Fxperiments here have shown that double superphosphate (40% P_2O_5) and surface burning both increase yields of grain and straw and they also stimulate tillering. Yields of up to 1,800 lb. per acre of grain (2,018 kg./ha.) were obtained in 1955 with these treatments.

4. At Chenderong Balai, Perak, where the peat is shallower and less acid and the land irrigated, yields have usually been poor but here also a response to phosphate (rock phosphate) has been detected. It is suggested that anaerobic conditions limit growth and yield.

5. For certain dry land crops growing on peat spray applications of copper, as Bordeaux mixture, are beneficial: for padi added copper is unnecessary and may reduce yields.

6. There is no evidence to suggest that other minor elements (e.g. Zn, Mo, B, Mn) are of benefit to padi growing on peat.

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ESTIMATION OF CROP LOSSES IN PADI IN MALAYA DUE TO INSECTS

R. J. A. W. Lever[1]

Very little information has been acquired about the losses directly caused by insect pests to padi in Malaya but it is known that there is a considerable variation in the relative abundance of stem-borers in the same locality from season to season and that there is a geographical difference in their accurence throughout the peninsula. As stem-borers are the chief pests, there will inevitably be annual differences in the losses caused.

The intensity of the variation can be seen from the following figures taken from a report by the former Senior Entomologist, Mr. H. T. Pagden (5). These give the number of egg-masses of padi borers collected in two small areas ($\frac{1}{2}$ and 1/6 acre) in two consecutive seasons in Krian, Perak:

Year	Species	Area A	Area B
1930/31	Chilotraea polychrysa (Meyr.)	2,450	5,129
	Schoenobius incertulas (Walk.)	5,049	7,756
1932	C. polychrysa	3,025	2,372
	S. incertulas	129	1,070

Similar results were obtained twenty years later in one locality in Province Wellesley where collection of stem-borer larvae showed the following variations in numbers over a period of only 4 months:

1 *Entomologist, Department of Agriculture, Federation of Malaya, Kuala Lumpur.*

Date	Chilotraea	Schoenobius	Sesamia	Total Stems
November, 1952	595	54	9	3,727
February, 1953	135	744	387	3,125

These collections were made by Mr. Goh Kee Guan and Enche Abdul Majid who subsequently split the stems and counted the borers present.

More recently, field examination of tillers damaged by stem-borer larvae were carried out by Mr. I.J. Wyatt whose figures showed:

Malacca	20 localities	Bored tilleres	14%
Negri Sembilan	5 "	" "	7%
Krian, Perak	16 "	" "	26%
Province Wellesley	4 "	" "	8%
		Average	13.7%

The difference in latitude between the first and last of the four States and Settlements listed above is approximately 3°15' and indicates what extremes could be expected in the percentage of bored stems throughout the peninsula from the Siamese frontier to the Straits of Johore, a distance of 385 miles from north to south. No details are available from the States east of the main dividing range.

Conversion of the percentage bored stems into actual loss of crop is a subject which has yet to be tackled. The complexity of this problem, which includes the alleged financial loss caused by the damage, has been well summarised by Jepson (2) who draws attention to the need for selecting a sampling unit of a reasonable size and for the need for statistical field studies. He also shows that the critical point of infestation depends on the soil fertility, water supply, temperature and size of plants on initial infestation. There is also the question of how much recovery is made by the damaged plant in retillering.

Preliminary investigations in the Krian area of Perak by Mr. I.J. Wyatt indicate that heaviest damage from borers occurs in padi growing in water shallower than 6 inches and that when there is a good crop there may be as much as 30% tiller damage which fails to be noticed by the cultivators who however search for the borers when the growth of the padi is poor.

Estimates of crop losses by borers is seen to vary from an overall figure of 2% in the Old World rice regions as given by Grist (1) to 10 to 20% in China by McNaughton (4) and 10 to 15% in Indo-China. These figures fit in with the 13.7% tiller damage quoted above but attempts to summarise the actual crop losses recorded, even from South-East Asia alone, soon show that much more information is required before an estimate can be given.

The only other padi insect whose damage to sice has been estiwated is the Coreid bug *Leptocorisa acuta* Thnbg. studid by Copeland thirty years ago and found to be responsible for a loss of 5 to 25 per cent, a figure still quoted today (1 and 4) though a mors recent figure of 20 to 40% is given for Indonesia (3). In the case of this pest one has to estimate the loss of potential crop at a very much later stage than in the case of stem-borers but further estimates are clearly required.

The need for more precise information on the whole question of pest damage to padi is appreciated and data from Malaya should be available within a year or so.

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INVESTIGATIONS ON THE TIME APPLICATION OF AMMONIUM-SULPHATE

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Introduction

In using ammonium-sulphate on rice crop in Indonesia, it was generally recommended to growers that the fertilizer be applied in two equal amounts, 4 and 8 weeks after transplanting, irrespective of the variety grown and its maturity. This was based on earlier experiences. It was felt, however, that the advisibility of the recommendation should be further verified. Hence a variety x fertilizer experiment was carried out in 1955 at the Tjikeumeuh Station.

Materials and Methods Employed

The varieties used in this experiment were:

1. **Tjina**, a late maturing variety of *indica* type, 170-175 days.

2. **Sigadis**, an early maturing variety of *indica* type, 140-145 days.

3. **Baok**, a late maturing variety of *sub-japonica* type, 165-170 days.

The seedlings were raised in nurseries and transplanted after 35 days of growth, allowing 3-4 plants per hill. The planting space was 12 by 12 inches. The size of the experimental plot was 5 by 11 feet.

The experiment was laid out in a randomized block with four replications. The rate of ammonium-sulphate used was 100 kilograms per hectare (90 lbe./acre), which was applied in two equal amounts. In addition to the control, there were 10 treatments. Expressed in weeks after transplanting, these were as follows: 2 and 4, 2 and 6, 2 and 8, 2 and 10, 4 and 6, 4 and 8, 4 and 10, 6 and 8. 6 and 10, 8 and 10.

There was no incedence of pests or diseases in the test.

Results Obtained

The results of the experiment are produced in Table 1, indicating that an application of 100 kilograms/hectare of ammonium-sulphate increased yields for all varieties under test, with significant increases over the check.

However, for the maximum yield increase, the fertilizer should be applied at 6 and 10 weeks after transplanting for *Tjina;* 4 and 6 weeks for *Sigadis;* and 2 and 10 weeks for *Baok*. When expressed in percentages, the maximum yield increase obtained was 44.7, 63.7 and 50.8 for *Tjina, Sigadis* ane *Baok* respectively.

Table 1 – Results of the Experiment on the Time Application of Ammonium-Sulphate.

Time of application	Variety					
	Tjina		Sigadis		Baok	
	yield	diff.	yield	diff.	yield	diff.
Check	11.06		9.66		5.96	
2 & 4	12.84	1.78	14.77	4.81	7.55	1.59
2 & 6	12.93	1.87	14.71	5.05	8.46	2.50
2 & 8	14.18	3.12	14.42	4.76	8.22	2.26
2 & 10	13.65	2.59	13.41	3.75	8.99	3.03
4 & 6	14.09	3.03	15.82	6.16	8.32	2.36
4 & 8	14.42	3.36	15.54	5.68	8.56	2.60
4 & 10	14.52	3.46	13.94	4.18	8.80	2.84
6 & 8	14.81	3.75	14.42	4.76	8.70	2.74
6 & 10	16.01	4.95	14.81	5.15	8.89	2.93
8 & 10	15.29	4.23	12.98	3.72	7.84	1.88

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